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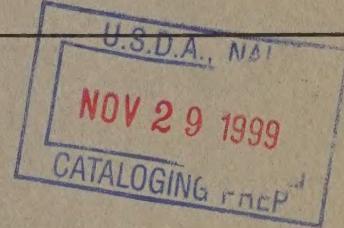
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Bureau of Entomology and Plant Quarantine
Division of Domestic Plant Quarantines

in cooperation with

The Division of Nematology, Bureau of Plant
Industry, Soils, and Agricultural Engineering

and

The New York State Department of Agriculture
and Markets

GOLDEN NEMATODE OF POTATO

Report for 1945

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Research Administration
Bureau of Entomology and Plant Quarantine
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by

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The Department of Agriculture and Markets of
the State of New York

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GOLDEN NEMATODE REPORT, 1945

Summary

Survey. The survey in Nassau and Suffolk Counties, Long Island, brought to light 5 new infested locations in 1945, all within two miles of the northern border of the quarantined area.

County	Proper- ties	Acres Examined	Acres Additional		Plants Examined	Specimens Submitted
			in these Properties			
Nassau	125	3300	2,010		15,173	46
Suffolk	240	5400	10,009		54,194	21
Totals	365	8700	12,019		69,367	67

No golden nematode was found by R. L. Clement in Steuben County, New York, where 1,419 plants were examined in 7 farms totalling 350 acres.

Quarantine. Freight movement records revealed considerable carlot movement from Hicksville in 1944-45 and this led to definite quarantine control of this movement for the 1945 season. This control established July 24 allowed no cars from infested areas to move interstate to seed-growing states and further confined such movement to consuming centers such as military camps or to starch or chip plants. The New York State quarantine was revised November 19, 1945, effective February 15, 1946, to include new infested areas, to establish a shipping permit system, regulate plant shipments, require cleaning of outgoing tools and implements, forbid the use of seed from infested land, and supervise topsoil movement.

Control Investigations. These are conducted cooperatively by this Bureau, the Bureau of Plant Industry, Soils, and Agricultural Engineering, the New York Department of Agriculture and Markets, Cornell University, and in one feature the Nassau County authorities.

Methyl bromide fumigation has been unpromising.

Soil fumigation with D-D indicated 90-99% control but did not accomplish eradication. To be continued in modified form for 1946.

Potato cleaning studies by brushing, scrubbing, and jet-washing developed no method for freeing tubers of nemas completely. The jet-washing process will be further developed and tested in 1946.

The nema cyst counts made on graded potatoes and soil in sacks indicate that commercial carlots may carry tremendous numbers of this nema.

Host range studies are being undertaken by Cornell University.

Facilities for soil temperature studies have been set up by cooperative efforts.

Hot water treatments designed to kill cysts and hot water plus chemicals have been given preliminary trial. Hot water plus 1% ammonia at or above 125° F. shows promise.

Introduction

Golden nematode quarantine and control activities during 1945 herein reported include (1) a survey of potato fields in Long Island outside of the area previously known to be infested and already brought under quarantine; these Long Island potato areas were not examined in the 1944 survey; (2) plant quarantine action by the State of New York; and (3) control investigations, the results of which may have significance in quarantine and control planning.

Golden Nematode Survey, 1945

Survey activities in 1945 constituted a joint project by this Bureau, the Division of Nematology of the Bureau of Plant Industry, Soils, and Agricultural Engineering, and the New York Department of Agriculture and Markets, with field supervision under the leadership of the Division of Domestic Plant Quarantines. The survey undertook this season to make a more complete survey of all potato areas in Nassau and Suffolk Counties outside of the known infested area in Long Island and to examine another potato area in Steuben County, New York, to which several Long Island growers had moved a few years ago.

To the survey personnel this Bureau assigned three experienced inspectors who had participated in the survey of 1944 and also supplied three pick-up trucks and the necessary field inspection equipment; the Division of Nematology furnished one trained nematologist; and the New York State Department of Agriculture and Markets made available two of their most experienced inspectors as in 1944. All field specimens were referred for determination to the Division of Nematology, Beltsville, Maryland. These six men thus made up three two-man crews for the survey in Nassau and Suffolk Counties, the survey in southern New York being taken care of specially by R. L. Clement of the New York inspection staff.

Survey work was begun July 1 and was terminated at the end of August. It now appears that it would have been possible to have started at least two weeks earlier in this area on account of the unusually advanced season and the general earliness of the potato crop in the Island. Further the survey could not be prolonged into September because of extensive digging operations, the early dying out of Cobbler tops, and to the widespread practice of killing off the late vines by weed-killer applications.

Since the survey methods of 1944 were essentially followed, preliminary training was not needed for this experienced crew, although they were given an opportunity to observe the golden nematode again in actual plant roots and in infested soil. Tools, shoes, and cars used in the infested area for this purpose were carefully cleaned before leaving there.

The survey conducted in Nassau County outside of the known infested area covered 125 potato farms having 3300 acres of potatoes. Five of these farms were found to harbor golden nematode on the basis of specimens found on potato roots and identified as this pest by the Division of Nematology.

The owners or operators of these farms were promptly notified of the existence of infestation on their properties, and the New York Department of Agriculture and Markets was likewise advised of each infestation in view of its quarantine interest. All these five new locations are scattered in the northern environs of the known infested area, none of them more than a couple of miles from the already established quarantine line.

In Suffolk County there were examined 240 potato farms containing 5400 acres of potatoes without disclosing any trace of golden nematode.

The work in both these counties involved the survey of 365 farms growing 20,719 acres of potatoes. In 8,700 acres of these the roots of 69,367 potato plants were examined, and 67 root specimens were sent in for more careful examination, usually on account of symptoms thought to be other than golden nematode.

Mr. R. L. Clement reports that examination was made of potatoes on 7 farms in Steuben County, New York, ending September 6, in a neighborhood to which several farmers had moved from Long Island several years ago. In the potato fields on these 7 farms totalling 350 acres, 1,419 potato plants were examined without disclosing any indication of the golden nematode.

It is estimated that in 1945 the two counties, Nassau and Suffolk, grew about 60,000 acres of potatoes. It would thus appear that the 8,700 acres examined in this survey represent only about 14.5% of the total potato area of the Island. However, a considerable portion of this total acreage represents wartime expansion -- planting of land not hitherto devoted to potatoes. Furthermore, many farmers were now putting into potatoes fields which had seldom if ever been used for this crop in recent years. It is estimated that about one quarter of the total acreage would fall into these categories and could properly be excluded from the survey. Leaving out these areas where search would be useless, the survey roughly covered about 20% of the Island's potato plantings, and if the 20,719 farm acres from which the 8,700 most likely acres were selected for examination are considered then the survey gave about 45% coverage, which in a large scale effort of this sort should be considered reasonably adequate.

In making this survey every effort was made to select the limited numbers of plants that could be examined from the type of field locations which experience has shown to be most likely of infestation. Special attention was directed to low spots, drainage courses, weedy or poor spots, and to plants along roadways, field lanes, and around buildings, loading places, and grader sites where these were available. Because of intelligent selection in this way it is believed that the survey was many times more effective than for the same number of plants chosen at spaced intervals over the fields.

Quarantine Activities

Information assembled April 12, 1945, from local New York freight office records indicated that a considerable number of cars of potatoes had been shipped to various parts of the country from Hicksville, New York, during the 1944-45 shipping season. Recognizing the possible danger of disseminating the golden nematode to new and distant points in shipments derived from infested land in this area, a system of recording all shipments from the quarantined area was set up July 24, 1945, and at the same time a feature of destination control was put in effect to insure that potatoes from infested fields would not move to seed-growing states. This protective action was strengthened by restricting interstate carlot movement to large consuming agencies such as military camps. At the same time the quarantine provided for general movement to the vast metropolitan area of New York and to nearby starch and potato chip factories. Since the 1945 potato acreage in Long Island was larger than normal and the yield per acre far above average, it was quite an accomplishment to move such a bumper crop to market under these restrictions.

A few cars had gone from the quarantined area before shipping restrictions could be made effective but prompt notice was sent by New York in each case to the quarantine authorities in destination states and in practically all instances both the potatoes and sacks were located and disposed of so as to avoid danger of spread.

During the period from July 24 when shipping restrictions became effective, to December 31, a total of 208 carlots of potatoes grown in the quarantined area were shipped under the controlled conditions mentioned to destinations other than New York City or chip and starch factories. The metropolitan area received 182 truck lots, and movement to nearby chip and starch plants totalled 2 cars; 173 car and truck shipments went largely for ship's stores, with a few for export.

A revision of the New York State quarantine on golden nematode was announced November 19, 1945, effective February 15, 1946, which extends the area under quarantine in Nassau County, Long Island, to include the 5 additional properties found infested in the survey of 1945. Topsoil may not be moved out of the quarantined area from infested or exposed land, and from other land only under permit. The outward movement of potatoes for seed use is prohibited. Potatoes and other root crops from infested land may be moved only under permit free from excess soil, to New York City for consumption there, or to specified processing plants. Provision is made for the safe disposal or return of containers and for the cleaning of cars or vehicles used in transporting such produce. These restrictions may be modified when methods of treatment are available. The outward movement of plants for transplanting is to be allowed only under permit. Finally, all farm tools, machines, and equipment likely to distribute golden nematode in attached earth may move out of the quarantined area under permit only and when thoroughly cleaned.

Evidence secured during the latter part of 1945 indicated that graded tubers from infested land as well as soil sifted to the bottoms of the sacks carried unexpectedly large numbers of nema cysts, and since these

can not be killed or removed completely by any treatment now available, the danger of spread in table stock shipments originating in infested fields became clearly evident. Recognition of this situation has resulted in local state proposals to solve the problem with finality by taking all infested or exposed land out of potato or root crop production for a number of years, at the same time giving every acre a treatment with D-D or other effective nemacide to reduce the possibility of both local and distant spread to a negligible minimum.

Control Investigations

In addition to the research work under way on the golden nematode in the Division of Nematology, a series of control investigations is being carried out through the cooperation of that Division, this Bureau, the Department of Agriculture and Markets of New York, and Cornell University. Pending publication of more complete reports a summary of the results achieved to date is here given, since certain of the results seem to clarify our understanding of the problem and are of value in future planning.

Methyl Bromide Fumigation of Tubers. In an effort to render table stock potato shipments safe for distant distribution from the region of infestation, tests with methyl bromide were carried out in October 1944, using several dosages and exposure periods for potato lots of commercial type. The general result of these tests was disappointing. A heavy dosage appeared to be necessary to kill the nematode (larvae and eggs) and at effective concentrations there was some injury to the tubers. Since no other fumigant is known to have any practical advantage over methyl bromide, this line of effort has been discontinued for the time being, although there still remains a possibility that some formula for methyl bromide may be worked out to give effective kill with little or no tuber injury.

Soil Fumigation. Five one-acre plots at one side of a heavily infested field were treated in October 1944 with various dosages of D-D from 450 to 1200 pounds per acre, with 5 similar plots as checks. After the ground was plowed and disked, the D-D was applied by a tractor outfit fitted with tank, pump, and hose connections to 6 nozzles directing streams of D-D downward immediately behind 6 shovel-type cultivator teeth, spaced one foot apart. After application the surface was well rolled to retain the fumes, and a strip of rye was planted on each side to reduce wind borne contamination. A golden nematode soil index was made previous to this application. These soil index results provide a striking indication of the population of golden nematode in infested soil. A determination was made of the nemas in 12 one-ounce samples from each of 10 plots. The average for these 120 samples was 117.6 cysts containing 8650.4 eggs and larvae per ounce of soil. At this rate an acre of soil would contain 940,400,000 cysts containing 69,202,800,000 eggs and larvae, and these numbers would allot 47,020 cysts or 3,460,140 eggs and larvae to each of the 20,000 potato plants growing in that acre.

In the spring of 1945, two 8-row strips of potatoes were planted in each tenth-acre plot, and the remainder of the plot was sown with oats. The potatoes were examined for root nemas when grown sufficiently, and after harvest a soil index was again made and checked against the original soil index. The general outcome of these plot fumigations may be given as follows:

1. Complete eradication was not obtained in any of the plots, even with the maximum dosage of 1200 pounds per acre.
2. While the higher dosages were somewhat more effective than the smaller amounts, the differences were not proportional to the rates of application, suggesting that failure to attain a 100% result may not lie in the efficacy of the D-D itself, but in either the mechanics of application or in wind-borne recontamination, or both.
3. The results were excellent from a control standpoint, giving from about 90 to 99% killing at dosages of 450 pounds per acre and upward. However, even this high degree of destruction could still leave in the soil 124,000,000 to 320,000 viable cysts per acre, enough to expose every potato plant root to 2839 to 9 cysts. While treatment represents a reduction of viable cysts from an original 24,365 per plant to the above figures, the remaining 2839 per plant or even the 9 cysts per potato root constitute a very effective nucleus for the subsequent build-up of population.
4. There were indications that the 450 pounds per acre rate would give almost as good control as higher dosages.

The high degree of suppression obtained in the 1944 applications encouraged a continuation of this effort in 1945. A rearrangement of the same 10 plots and the inclusion of some adjacent land enabled the project to continue with certain modifications. These included reliance on more moderate applications, with 450 pounds per acre regarded as about standard; use of a 250-pound application as of possible interest for farm control use; two applications at about a month's interval, the second to follow a plowing which would turn under the surface soil, suspected of being less affected by the fumigant than deeper layers; a variation of these two applications by making the second a surface spray; the effect of applications in two successive seasons; and a possible residual effect in the second season. In addition to the above standard (450 pounds per acre) treatment was given to an acre of soil in an infested field to be planted by the owner with potatoes in 1946.

The first D-D applications in these plots in 1945 were made September 28 to October 2, following the methods used in 1944; the second applications were given October 22 to 29. The plots will be again planted in 1946.

Potato Cleaning Studies. When the golden nematode first came to attention the conception was current that distant spread would take place largely by soil movement, either by itself, or attached to tubers, or sifted to the bottom of bags, and that the tubers themselves were relatively if not entirely free from the nema. Studies were made of this situation in 1945 in connection with attempts to rid potatoes of adherent soil in the hope of thus rendering the tubers safe to ship interstate.

In looking over freshly dug tubers from infested land with a hand lens it was found that they frequently bore cysts which had developed on the tuber itself and were not merely present in attached soil. Such cysts may occur on any skin surface but are present more commonly at the stem depression and in the eyes. They are still in evidence on mature tubers when tops and roots are completely dead. At that time perhaps 5% of the nemas are still immature as determined by their color. Most are so lightly attached that a touch will dislodge them but a few of them are still partly imbedded in the skin and are difficult to remove. About 10% seem to be located in deep eyes (Cobblers) where ordinary brushing or cleaning methods are unlikely to reach them.

Counts of these encysted females were made on sample lots of potatoes, from several infested field sources:

1. Freshly dug mature tubers, tops dead, before grading.
2. Graded tubers bagged and ready for market taken from a grower's intended shipment.
3. Graded potatoes hand scrubbed in water with a kitchen bristle brush to remove soil. This cleaning process was considered at least as effective as the work of any commercial washing operation.
4. Graded potatoes run through a standard Boggs cleaning unit where the tubers, carried along on moving and turning rollers, were brushed by two revolving bristle brush cylinders and two cloth flap cylinders, the loosened soil particles being removed by a strong fan suction device.
5. Tubers were run over a carrier of moving and revolving rollers fitted with spiral windings to turn the potatoes constantly. Over this carrier numerous fine high pressure water jets were directed downward and from several angles with the object of removing all cysts, especially from deep eyes.

A tabular summary of the results of these tests is as follows:

Potato Cleaning Studies - Golden Nematode, 1945

Nematode Cyst Counts on Tubers in Connection with Attempted Cleaning Operations

Potatoes Tested	Pounds of potatoes used	Sample used for count (tubers)	Cysts found on sample	Average cysts per tuber	With cysts	Tubers	Without Cysts
1. Ungraded mature fresh-dug potatoes 4 sources	-	207	295	1.4	104	103	-
2. Graded and bagged for market	1200	300	381	1.3	174	126	-
3. After hand scrubbing in water with bristle brush	1200	300	135	0.45	80	220	-
4. After dry brushing with air suction dust removal	300	150	177	1.18	74	76	-
5. Water-jet washing (preliminary test) before washing after washing	-	125 125 250	125 31	1.0 .25	21	104	-

In addition to these observations on nemas occurring on the tubers themselves some attention was given to the nema count in the soil attached to them or found in the sacks in which they were carried.

The average dry weight of the soil washed from 12 sacks of potatoes (100 pounds each) was estimated from its wet weight as 31.8 grams. The number of nema cysts in the soil washed from 6 of these bags (122.4 gms) was 3352, or an average of 558.6 per hundred pound sack. The average nema count in this soil debris in sacks is far higher than that for field soil, indicating that there is a definite sifting of nema cysts to it from the tubers themselves.

It is believed that the potato samples used in these tests although taken from well infested fields, do not represent the extreme of tuber infestation. Certainly they represent conditions actually existing now and which may generally prevail as infestation builds up further in this area.

The data secured in the course of this work seem to justify the following conclusions:

1. Potatoes from infested land at digging time bear a considerable number of nemas which have developed on the tubers and are particularly evident around the base of the stem and in the eyes.
2. The grading process does not materially lessen this tuber-borne cyst population.
3. The small amounts of soil sifting to the bottom of graded sacks contains relatively large numbers of cysts, far more than normal field soil counts.
4. A hand washing and scrubbing process comparable in efficiency with commercial machine washing definitely reduced the tuber cyst count but was only about 80% effective in removing nemas.
5. The dry brushing process was even less effective than hand scrubbing and washing.
6. Preliminary tests with an experimental water-jet outfit reduced tuber cyst counts from 125 to 31 nemas per 125 tubers, a reduction of 75.2%. While this result is far from satisfactory for practical application, it is believed that with modifications and improvements this process can be developed to give a high degree of efficiency.

The true significance of these figures on cysts in the soil of the sacks and on the tubers themselves can be better understood for the general golden nematode problem by projecting the values obtained into terms of commercial potato movement. A 300-sack car of graded potatoes having the nema counts here determined would carry to distant points some 114,300 cysts on the tubers themselves in addition to 167,580 in the soil at the bottom of the sacks — a total of 281,880 cysts. And the potentialities for spread by this channel are further multiplied by the recognition that each live cyst contains an average of 200 eggs and larvae.

Host Range Studies. The host range of the golden nematode appears to be restricted to the potato, tomato, and a few wild species of the Solanaceae. Most of our knowledge on host relations comes from Europe although F. W. Gordon of Cornell University made some observations in 1943 on the roots of a number of plant species growing in infested soil. The need for more complete and accurate knowledge on the host relations of this nematode is evident, not only in connection with control activities or eradication efforts, but in the possible relation of subsidiary hosts to spread and persistence of the organism. Cornell University has undertaken to make further studies of this host problem, but through field observations and by planting various plant species in infested soil.

Soil Temperature Studies. Absence of any record of golden nematode occurrence in Southern Europe raises the suspicion that this pest may find southern climatic conditions especially unfavorable to it. A restriction of this kind need not depend on soil temperatures of the growing potato crop but might also be related to interseason conditions. In view of the extent and importance of potato culture in the southern states, it is highly desirable to obtain more definite knowledge than uncertain inference from European conditions provides, as to whether this nematode could successfully maintain itself in warmer southern climates.

As a step toward such knowledge it is proposed to grow potato plants in infested soil held at several constant temperatures and to supplement this series by providing a suitable range of interseason conditions.

Facilities for this project being unavailable within the infested area where the work must necessarily be carried out, arrangements were made by the several cooperating agencies to set up suitable greenhouse and laboratory equipment for this and other investigational needs. The County of Nassau made available a lot on the outskirts of Hicksville to Cornell University. The Bureau of Plant Industry, Soils, and Agricultural Engineering provided a greenhouse and a series of constant temperature units and other equipment; and the Bureau of Entomology and Plant Quarantine loaned to the project a temporary portable building to serve for laboratory and storage. The building was in place November 15, and the greenhouse was put in operation January 14, 1946, at which time 4 of the 8 proposed constant temperature units were ready to function.

Hot Water and Chemical Treatments. Every effort has been made to work out effective methods of treating potatoes to destroy or eliminate the golden nematode and thus open up a safe channel for shipment from the infested farms of Long Island. Methyl bromide has proved disappointing and the washing and brushing studies mentioned above not only held little present promise but served to emphasize the danger of spread in table stock shipments. Attention was therefore turned to the possibility of developing hot water treatments, using the hot water either alone or in conjunction with various chemicals — formaldehyde, acetic acid, ammonia, and caustic soda. Preliminary tests were made with nematode lots floated from soil into filter paper packets. These were treated along with potato tuber samples at 125°, 128°, 130°, 132°, 135°, and 140° F. in water alone and in water plus the several chemicals mentioned for periods of 1, 2, and 5 minutes.

Hot water below 130° F. for 2 minutes did not kill the nematode. Of the chemicals used only ammonia appeared to be effective, as determined from examination of the treated nema samples after holding for more than a month subsequent to treatment. Killing was obtained with 1% ammonia in all cases even at the low temperature of 125° for 1 minute.

It is proposed to continue these studies in 1946, when facilities will be available for making tests of the treatments on an adequate scale by placing treated nema lots with growing potato roots in clean soil.

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